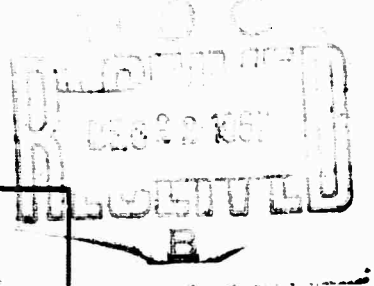
SEMI-ANNUAL TECHNICAL SUMMARY
for the period ending 30 SEPTEMBER 1967

to

ADVANCED RESEARCH PROJECTS AGENCY

RESEARCH ON ELECTROMAGNETICS FOR PROJECT DEFENDER

ARPA Order No. 529 Program Code No. 5730



Report
R-1295.5-67

for
Office of Naval Research
Contract Nonr-839(38)

POLYTECHNIC INSTITUTE OF BROOKLYN

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Date of Contract: 1 February 1964

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Report
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for
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Submitted by: Rudolf G. E. Hutter
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Professor of Electrophysics

POLYTECHNIC INSTITUTE OF BROOKLYN

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ABSTRACT

This report contains a compilation of abstracts of papers which were either accepted for publication or were published. The papers are on the subjects of Fluid Dynamics, Electromagnetics and Plasmas. The work described was carried out under an ARPA contract, Order No. 529. This report also contains a listing of papers submitted to journals, lectures, internal reports and staff activities.

TABLE OF CONTENTS

I. INTRODUCTION

The Polytechnic Institute of Brooklyn is conducting a broad interdisciplinary theoretical and experimental research program in plasma aerodynamics, electromagnetic scattering theory and experimental plasma research applicable to both the immediate and long-range interests of the ARPA Ballistic Missile Defense Program. Emphasis is being placed on fluid dynamics, electromagnetic radiation and their interaction with media characteristic of the ballistic missile defense environment.

II. SUMMARY OF RESEARCH

In this section are presented abstracts of technical papers which have been either published or accepted for publication during the reporting period covered by this report.

A. FLUID DYNAMICS

Lederman, S. and E. F. Dawson, "Application of a Microwave Technique to the Measurement of Electron Density and Ionization Time", to be published in Physics of Fluids, December 1967.

The measurement of ionization rates, electron density and ionization time in thermally ionized gases, by means of a microwave technique, is discussed. The technique used in this work utilizes a so-called "end wall" microwave resonant cavity. It is essentially a microwave cavity operated in the TE_{011} mode with a plasma forming one end wall. Since the resonant frequency of such a cavity is a function of the axial length of the cavity, a variable density plasma with its corresponding variable conductivity is utilized to tune the cavity to different resonant frequencies. It is shown that by applying two frequencies to the cavity separated from each other by a known Δf, which is small compared to the resonant frequency of the closed cavity, a simple method is arrived at to measure electron density, ionization rate and ionization time.

Lederman, S., M. H. Bloom and G. Widhopf, "Experiments on Cylindrical Electrostatic Probes in Slightly Ionized Hypersonic Flow", to be published in the AIAA Journal (after presentation at the AIAA Sixth Aerospace Sciences Meeting to be held in New York in January 1968).

The behavior of biased electrostatic probes in ionized media is of substantial interest to those concerned with space flight environment, reentry, and laboratory simulation, among others. The effect of finite cylindrical probe length, probe diameter, ratio of probe radius to Debye shielding distance, angle of attack in the case of a flowing plasma, and length-to-diameter ratio on the current collection ability of a probe is experimentally investigated in a slightly ionized frozen hypersonic shock tunnel flow. The results are linked to the detailed analysis of Laframboise for probe operation in a full molecular collisionless plasma. It was found experimentally that for $R_p/\lambda_D < 3$ the results of the experiments deviate from those of the idealized collisionless free molecular theory, that the current density increases with the decrease of length-to-diameter ratio and that the angle of attack trends vary with the length-to-diameter ratio.

Lederman, S., M. H. Bloom and G. Widhopf, "Electron Density Distribution in the Near Wake", to be published as a preprint for the AIAA Sixth Aerospace Sciences Meeting to be held in New York in January 1968.

Recently attention has been focused in theoretical descriptions and experimental measurements of the effects of physical and chemical processes in wakes of high velocity bodies. In particular, the electron density distribution in the wake of typical reentry vehicles has received much attention. In the present work an attempt is made to obtain detailed pointwise electron density distributions in the near wake of models of typical reentry configurations utilizing a slightly ionized hypersonic flow of a shock tunnel for that purpose. As the diagnostic instruments, Langmuir type probes, arranged in the form of a rake, were used. It was found that the shock tunnel can - within limits - be used to advantage to obtain such information on the electron density profiles in the near

wake including the recirculation region, the relative electron density in the recirculation region for both blunt and slender bodies may vary over a range of 3 orders of magnitude.

Hoffert, M. I., "Nonequilibrium Structure of Hydromagnetic Gas-Ionizing Shock Fronts in Argon", to be published in the Physics of Fluids, January 1968.

This study deals analytically with the structure of gas-ionizing hydromagnetic shock waves. Since these waves, by definition, must have non-electrically-conducting upstream states, their existence at very high shock temperatures must be ruled out on the physical grounds that forward-radiated precursor ionization makes the unshocked gas conducting. A "low temperature" collisionally-ionizing shock with oblique magnetic field is studied here to determine whether certain concepts which exist in the current literature are relevant. Non-dimensionalized equations governing the nonequilibrium structure of such a front propagating into un-ionized argon are formulated using ionization rates and an electron energy equation developed in an earlier paper. Comparison of the magnitudes of viscous and magnetic Reynolds numbers within this front indicates that, if a structure exists, it must consist of a narrow "imbedded" viscous shock standing upstream of a much wider hydromagnetic interaction and ionization relaxation zone. Hence, a modified form of the Zeldovich-von Neumann-Doring (ZND) approximation is applicable to the structure problem. It is shown that in this approximation nontrivial steady-state structures cannot be constructed for "fast" gas-ionizing shocks. On the other hand, solutions are possible for "slow" waves, and these are obtained numerically for a family of hydromagnetically oblique shocks at Mach number $M_1 = 20$ and Alfen number $M_{A_1} = 1\ 2$ with parametrically varied values of the upstream electric field. In contrast to previous expectations, the upstream electric field is not uniquely defined by the structure. Because the slow solutions are effectively exothermic, to the point where their post-shock temperatures are associated with radiation-induced precursor ionization, it seems likely that only the solution with the upstream electric field corresponding to a pure hydromagnetic shock has physical significance.

B. ELECTROMAGNETICS

Berger, H. and J. W. E. Griemsmann, "Poynting's Theorem for Moving Media",* published in IEEE Transactions, Vol. AP-15, No. 3, p. 490, May 1967.

Compton and Tai have published a generalization of Poynting's theorem for media moving with nonrelativistic velocity, and have given physical interpretations for various terms of their resultant equation. In the present communication, Comption and Tai's result (generalized to include relativistic velocity) is transformed into another form which suggests a very different interpretation.

Berger, H. and J. W. E. Griemsmann, "Guided Waves in Moving Dispersive Media: I. Nonrelativistic Velocities",* to be published in IEEE Transactions on Microwave Theory and Techniques, January 1968.

This paper presents a theoretical examination of the influence of dispersive media on the time-harmonic, TE and TM modal field structure of the electromagnetic waves in a cylindrical waveguide of arbitrary cross-section when the medium is in relative motion with respect to the waveguide walls. The modal field structure observed both in the reference frame F' attached to the medium, and in the reference frame F attached to the waveguide walls, are determined in closed form. The results presented for the modal fields observed in F are valid when the medium moves with non-relativistic speed v. Contact is made with the standard relativistic discussion of TEM waves in slowly moving dispersive media involving the Fresnel drag coefficient, and it is pointed out that the customary restrictions on v for numerical accuracy of the results can be inadequate. The theory is applied to two special cases. The nonreciprocal phase shift exhibited by a waveguide filled with moving media is also discussed.

Berger, H. and J. W. E. Griemsmann, "Guided Waves in Moving Dispersive Media: II. Relativistic Velocities",* to be published in IEEE Transactions on Microwave Theory and Techniques, January 1968.

* Work was done in part under Contract No. AF 49(638)-1402

The detailed modal field structure has been determined for electromagnetic waves propagating in a uniform, cylindrical, lossless waveguide of arbitrary cross-section filled with a moving medium. The medium is assumed to be homogeneous, isotropic, and non-dissipative, but may be dispersive. The medium moves uniformly, with a constant speed v, parallel to the axis of the waveguide. The solutions obtained are exact, closed form functions of the space variables, time, the modal wave frequency and propagation factor, and hold for any value of the magnitude of v, from zero up to the speed of light in vacuum. The electromagnetic power flow in the waveguide is investigated, and it is demonstrated that it displays characteristics which differ considerably from those associated with the stationary medium case. The general theory is applied to several types of moving media including (1) nondispersive media, and (2) the idealized low temperature plasma.

Berger, H. and J. W. E. Griemsmann, "Comments on 'Guided Waves in a Simple Moving Medium' ", publishe ' in the Proceedings of the IEEE, Vol. 55, No. 7, July 1967.

This letter presents comments on a recent letter by T. Shiozawa entitled "Guided Waves in a Simple Moving Medium", published in the Proceedings of the IEEE (Letters), Vol. 54, December 1966.

Berger, H. and J. W. E. Griemsmann, "Moving Media Without Electromagnetic Drag"*, published in the IEEE Transactions on Antennas and Propagation, Vol. AP-15, No. 4, July 1967.

The present communication is concerned with the determination of the general class of media (assumed homogeneous, isotropic, and lossless) whose movement does not produce a drag. It is demonstrated that only media with the dispersion characteristics of the plasma, described above, exhibit this extraordinary property.

* Work was done in part under Contract No. AF 49(638)-1402

Ott, E. and J. Shmoys, "Transient Aspects of Transition Radiation", accepted for publication in the Quarterly of Applied Mathematics.

When a charged particle moving at uniform velocity crosses a boundary between two media with different electrical properties, a pulse of electromagnetic energy is emitted. This phenomenon is basically unlike either bremsstrahlung or the Cerenkov effect in that the charge will radiate even though it does not accelerate or move faster than the phase velocity of light in the medium.

Various theoretical[1] and experimental[2] aspects of transition radiation have recently been the subject of extensive study. It has been proposed that the effect might be useful in the generation of microwave power and as a diagnostic tool for the study of metals and plasmas.

It is clear that the effect is fundamentally a transient process. It is, therefore, surprising that the transient character of the fields has hardly received notice. Previous investigators have concentrated on determining the frequency spectrum of the radiation fields. We, on the other hand, will deal directly with the problem of finding the fields as a function of time.

In order to illustrate the essential characteristics of the processes involved, a specific problem will be considered. For the problem selected an exact closed form solution is obtained in a form amenable to physical interpretation. It is found that before the time of impact the entire field may be represented in terms of an image picture, which is a generalization of the static case. Even after impact the image picture remains valid, but only in certain regions of space. At impact, a sudden burst of energy is liberated. This energy then propagates outward from the impact point in a manner to be discussed later. It is to be expected that the solution of the present problem will aid in the understanding of transition radiation in more complicated configurations, for which no closed form solution is available.

The method used to evaluate the transient is patterned after that given by Felsen[3]. A representation of the solution in terms of Fourier integrals will be obtained; these will then be reduced to such a form that they can be evaluated by inspection.

Ott, E. and J. Shmoys, "Transition Radiation and the Cerenkov Effect", to be published in the Quarterly of Applied Mathematics.

The analysis of transient radiation emitted by a line charge moving at a constant velocity at right angles both to itself and to a plane interface between two dielectric half-spaces has been generalized to include the possibility of Cerenkov emission in either medium. Just as in the special case of charge velocity lower than the wave velocity in either medium, the exact solution of the problem is obtained, but with additional pole contributions. The wavefront configuration corresponding to various relative values of the three velocities is obtained and discussed. In particular, the build-up of Cerenkov radiation as the line charge enters a medium with sufficiently high dielectric constant is studied.

C. PLASMAS

Freidberg, J. P., "Nonlinear Plasma Waves. Part III: Nonlinear Temperature Effects in the Electron-Ion Two Stream Instability", to be published in The Physics of Fluids.

The nonlinear interaction of two warm interpenetrating electron and ion streams is treated by investigating the traveling wave solutions to the two fluid macroscopic plasma equations. These equations are reduced to the form of a nonlinear differential equation with an additional small nonlinear term. Application of the perturbation procedure, described in Part I, leads to a nonlinear, amplitude dependent dispersion relation. An examination of this dispersion relation indicates that below a certain critical temperature, there is a range of wavenumbers where the two stream instability levels off before the onset of trapping. This range of wavenumbers decreases with increasing temperature and therefore is largest when the temperature is zero.

Friedman, H. W. and E. Levi, "Singularities of the Two-Fluid Plasma Equations and Their Relation to Boundary Conditions", published in The Physics of Fluids, Vol. 10, No. 7, July 1967.

The one-dimensional fluid equations are used to describe a steady state, slightly ionized plasma confined by cold walls. The singularities of the complete two-fluid and approximate one-fluid equations are

investigated and compared. It is found that the singularity in the one-fluid equations, indicated a transition from plasma to sheath regions, disappears in the two-fluid equations and therefore a smooth transition is predicted. Another singularity which is present in the two-fluid but not in the one-fluid equations is shown to be compatible if a constraint relation is satisfied at the singular point. In order that the two-fluid problem be well posed - (1) the boundary conditions are modified to ensure that the constraint relation is satisfied, and (2) a kinetic model is derived which uniquely specifies the wall potential for a given plasma configuration. The occurrence of a compatible singularity is shown to be analogous to the phenomenon of transonic flow in a convergent-divergent nozzle.

Friedman, H. W., "Non-Linear Asymptotic Analysis of the Positive Column", to be published in The Physics of Fluids.

The positive column of a slightly ionized gas discharge confined by cold, insulating walls is described by a set of non-linear fluid equations. The inertia, space charge and collision terms are retained. A zeroth order solution uniformly convergent to the exact solution in both plasma and sheath regions is derived using asymptotic boundary layer analysis. The value of potential at the wall is calculated by means of kinetic model. It is found that the density at the wall can be a significant fraction of the value at the center and that it vanishes only in the low electron temperature limit. The original Bohm criterion is recovered as a necessary condition for sheath stability and is interpretated as (1) the velocity which asymptotically separates the plasma from the sheath and (2) the maximum ambipolar diffusion velocity.

Koga, T., "Kinetic Theoretical Bases of Dynamics of Gases",* book accepted by Pergamon Press. The foreward is printed here:

Foreward

The theme of this monograph is the stochastic nature of kinetic-theoretical processes which occur in gases exhibiting gas-dynamical phenomena. The particles constituting a gas are assumed to be classical mechanical; in other words, a gas considered here is of low density and

* Work was done in part under Contract No. Nonr 839(34)

of high energy.

It is expected that the reader is familiar with thermodynamics and usual gas-dynamical phenomena as well as basic concepts of classical and quantum mechanics. It is desirable that he has been acquainted with Gibbs' interpretation of the Liouville equation and Gibbs' ensembles in statistical equilibrium. We do not follow the interpretation and definition initiated by Gibbs with respect to systems in thermal equilibrium. Our interpretation and definition are more restrictive in view of the purpose of considering systems whose states deviate from thermal equilibrium. But it is found convenient to recall those by Gibbs for the sake of comparison.

Gibbs' statistical mechanics had developed from the kinetic theory of gases which was constructed by Maxwell and Boltzmann based on the assumption that a gas is constituted of discrete particles, each of which behaves according to universal mechanical laws, even though we can neither see nor predict the behavior of each particle. Maxwell assumed the existence of a demon which can see a molecule in a gas. To such a demon the behaviors of the molecules in gas are completely in order. But those behaviors are chaotic to us; hence we introduce the hypothesis of equal a priori probabilities. It seems that the hypothesis was a convenience to Maxwell and Boltzmann in order to deal with the complex of a gas structure. To Gibbs, however, the hypothesis was a principle rather than a convenience. (At the same time, Gibbs did not necessarily insist that a system is composed of discrete particles.) Of course, the hypothesis is as essential for consideration of the kinetic theory of gases as for the general statistical mechanics supported by ergodic theory. However, in those two theories, kinetic theory and statistical mechanics, not only the interpretation but also the method of application of the hypothesis varies. The differences are due to the following situations:

1. Statistical mechanics is mainly interested in energy which is an integral of motion of an isolated system, while kinetic theory is concerned with many quantities, besides energy, which are not necessarily integrals of motion of an isolated system. A gas viewed by kinetic-theoretical eyes

is more in order than a gas viewed by statistical-mechanical eyes. In other words, we tend to be closer to Maxwell's demon by the kinetic theory.

2. The scales of time and space of statistical-mechanical phenomena are indefinitely large, whereas the scales of kinetic-theoretical phenomena are conditionally large. In other words, statistical mechanics views a system in a statistically stationary state, whereas kinetic theory views a system in the process of its evolution; kinetic-theoretical phenomena are stochastic.

Phenomena considered by the kinetic theory of gases constitute only a minor part of the vast world of statistical-physical phenomena which are mostly statistical-mechanical. As long as we are interested in kinetic-theoretical phenomena however, the peculiar nature of these phenomena should not be ignored. The reader may realize that the author is critical of various theories of gases which have been widely taken for granted. His criticism is aimed toward those theories which are overly statistical-mechanical. The author believes that he is not too skeptical, as long as he is interested in the kinetic theory of gases. It is confessed that his thought has been stimulated by his old interest in communication theory and by his experience in technical aspects of [illegible]s dynamics.

It was over one hundred years ago, in 1866, that Maxwell published his paper "On the Dynamical Theory of Gases". It is particularly interesting to recall various events which have occurred in the kinetic theory of gases since then. The author's interpretation of the history is summarized in Appendix III.

D. ABLATION

Fock, J., "Some Effects of [illegible]-Irradiation in Polytetrafluoroethylene Filled with Carbon Black", published in Polymer Letters, Vol. 5, pp. 635-640, August 1967.

Fock, J., "On Radiation-Induced Grafting of Acrylonitrile onto Films of Polytetrafluoroethylene", accepted for publication in The Journal of Polymer Science, Part AI (1968)

Fock, J., "Pyrolysis of a Tetrafluoroethylene Acrylonitrile Copolymer", accepted for publication in The Journal of Polymer Science, Part A II. (1968)

Fock, J., "On the Influence of Carbon Black on the Thermal Degradation of Polytetrafluoroethylene", accepted for publication in The Journal of Polymer Science, Part B. (1968)

III. ARPA-RELATED ACTIVITIES, LECTURES, VISITING PROFESSORS AND CONSULTANTS, PAPERS SUBMITTED TO OUTSIDE JOURNALS, AND INTERNAL REPORTS

A. ARPA-RELATED ACTIVITIES

Dean Martin H. Bloom is a member of the Atomic and Molecular Physics Panel of the Institute for Defense Analyses (IDA).

Dean Bloom is Associate Editor of the Journal of Ballistic Missile Defense Research, published by IDA for ARPA.

Professor Leopold B. Felsen is a member of a special sub-panel of the Arecibo Ionospheric Observatory (AIO) Evaluation Panel.

Participation at outside meetings relevant to the program included the following talks:

a) Varian Vacuum Technology Seminar V, New York, N. Y., April 1967: H. Farber

b) American Physical Society Spring Meeting, Washington, D. C., April 1967:

T. Koga presented "Kinetic Equations for Plasmas"

c) ARPA Institutes Review Meeting at the University of California at LaJolla, Calif., May 1967:

M. Bloom, "General Comments on the ARPA-supported research program at the Polytechnic Institute of Brooklyn"

R. Cresci presented "Flow Field in the Wake of a Slender Body" (author: M. Pierucci)

F. Eirich

L. Felsen, "Wave Propagation in Anisotropic Media"

H. Friedman, "Nonlinear Asymptotic Analysis of the Positive Column"

R. Hutter

E. Levi, "Observation of Resistive Instabilities in a Toroidal Discharge" (co-authors: E. Levi, H. Farber and K. Stuart)

d) Spring URSI Meeting, Ottawa, Ont., Canada, May 1967:

S. Maurer presented "Ray-Optical Description for Modes in Non-Uniform Waveguides" (co-authors: S. Maurer and L. B. Felsen)

L. B. Felsen presented "Ray-Optical Calculation of Reflection from an Open-Ended Waveguide" (co-authors: H. Yee and L. B. Felsen)

J. Shmoys, "Diffraction by a Cylinder in a Locally Uniaxial Medium with Azimuthal Optic Axis" (co-authors: J. Shmoys and H. Stalzer)

e) AGARD Specialists Meeting on Fluid Physics of Hypersonic Wakes. Colorado State University, May 1967:

R. J. Cresci presented "Near Wake of a Slender Cone in Hypersonic Flow" (co-authors: E. M. Schmidt and R. J. Cresci)

f) Summer Institute on Physics of the Magnetosphere, Boston College, Boston, Mass., June 1967:

L. Felsen J. Shmoys

g) Laboratory Workshop in Plasma Properties held at the University of Maryland, sponsored by the Atomic Energy Commission, June 1967:

H. Farber

h) H. Farber discussed development of the Arc Plasma Machine with Dr. K. Chung at Massachusetts Institute of Technology, June 1967.

i) American Physical Society Meeting, Toronto, Ont., Canada, June 1967:

E. Levi presented "Singularities of the Two-Fluid Plasma Equations and Their Relation to Boundary Conditions" (co-authors: E. Levi and H. Friedman)

E. Levi presented "Nonlinear Asymptotic Analysis of the Positive Column" (author: H. Friedman)

j) Meeting with Dr. P. Franken at ARPA, Washington, D.C., August 1967:

M. Bloom C. Gould

F. Eirich R. Hutter

A. Oliner

k) L. B. Felsen visited the Ionospheric and Plasma Laboratories at the Environmental Science Services Administration, Boulder, Colorado, August 1967.

l) L. B. Felsen visited Ioffe Institute, Plasma Division, at Leningrad; Lebedev Institute, Plasma Division, Moscow; Radiophysical Institute, Gorky State University, Gorky, all USSR, in August 1967. He presented lectures entitled "Radiation and Diffraction in Plasma Media".

m) E. Levi visited the Atomic Energy Plasma Laboratory at Laboratorio Gas Ionizzati, Euratom CNEN, Frascati, Rome, Italy, August 1967.

B. LECTURES

There have been many formal seminars and informal discussion groups; a partial listing is given here:

April 1967:

Dr. R. Zirkind	Optical Diagnostics of Flow Fields
Visiting Professor Ilya Prigogine Universite Libre de Bruxelles Belgium	The Second Law of Thermodynamics and Statistical Physics
H. Friedman	Non-Linear Asymptotic Analysis of the Positive Column
H. L. Runyan, Jr. NASA Langley Research Center Hampton, Virginia	Some Selected Topics of the Dynamics of Aerospace Vehicles
Professor J. M. Burgers University of Maryland Baltimore, Md.	Diffusion Problems in Ionized Gases
Professor Arthur Erdelyi University of Edinburgh Scotland	Singular Perturbation of Boundary Value Problems for Ordinary Differential Equations
J. Ruddy	Scattering from High Dielectric Constant Spheres
G. Whitman	Transient Response of a Cold Magneto-Plasma
H. Berger	Guided Waves in Moving Dispersive Media
D. Tseng	Guiding and Scattering of Electromagnetic Fields by Corrugated Structures

May 1967:

R. Sasiela	Cerenkov Radiation in Dielectric and Plasma Filled Cavities
Dr. Patrick Thaddeus NASA Institute for Space Studies New York, N. Y.	The Primordial Fireball

June 1967:

F. M. Labianca	Diffraction by a Cylinder in a Compressible Plasma

July 1967:

E. Levi	(Space Physics) - Magnetosphere

Dr. Nathan Marcuvitz has conducted a series of Plasma Turbulence Seminars throughout the period of this report.

Professor Rudolfo Monti, Istituto di Aerodinamica, University of Naples, Naples, Italy, gave a special lecture series on "Wave Propagation in Reacting Gas Mixtures"

C. VISITING PROFESSORS AND CONSULTANTS

Dr. Ilya Prigogine (University of Brussels)

Dr. Rudolfo Monti (University of Naples)

Dr. Nathan Marcuvitz (New York University)

D. PAPERS SUBMITTED TO OUTSIDE JOURNALS

Dorman, G., "Interaction of a Relativistic Electron Beam with an Inhomogeneous Plasma", submitted to The Journal of Applied Physics.

Friedman, H. and E. Levi, "Singularities of the Fluid Equations and Their Relation to Anomalous Diffusion", submitted to The Physics of Fluids.

Labianca, F. M., "Diffraction by a Half Plane in a Compressible Homogeneous Plasma", submitted to The Canadian Journal of Physics.

Friedman, H. and E. Levi, "Singularities of the Fluid Equations and Their Relation to Anomalous Diffusion", submitted to The Physics of Fluids.

Koga, T., "Symmetry of the Distribution Function of a System in Kinetic Theory", submitted to Physical Review Letters.

E. INTERNAL REPORTS

Bertoni, H., "An Approach to Ray Optics in Anisotropic Media", PIBMRI-1366-67, Department of Electrophysics, Polytech. Inst. of Brooklyn, June 1967

Friedman, H., "Nonlinear Asymptotic Analysis of the Positive Column", PIBMRI-1367-67, Department of Electrophysics, Polytech. Inst. of Brooklyn, June 1967.

Sasiela, R., "Cerenkov Radiation in Dielectric and Plasma Filled Infinite Space and Cavities", PIBMRI-1369-67, Department of Electrophysics, Polytech. Inst. of Brooklyn, June 1967.

Coordinated by R. Hutter, "Research on Electromagnetics for Project DEFENDER", Semi-Annual Technical Summary for the period ending 31 March 1967, PIBMRI-1295.4-67.

Koga, T., "Kinetic Equations for Plasmas", PIBAL Report No. 1007, Department of Aerospace Engineering and Applied Mathematics, Polytech. Inst. of Brooklyn, April 1967.

Sforza, P.M., "Some Preliminary Experiments on Probe Interference in Hypersonic Near Wakes", PIBAL Report No. 1011, Department of Aerospace Engineering and Applied Mathematics, Polytech. Inst. of Brooklyn, May 1967.

IV. PERSONNEL

M. H. Bloom	Professor Dean of Engineering Director, Gas Dynamics Research
R. J. Cresci	Professor
H. Farber	Associate Professor

L. B. Felsen	Professor
J. W. E. Griemsmann	Professor
A. Hessel	Professor
R. G. E. Hutter	Professor Principal Investigator
D. Jacenko	Research Associate
K. R. Jolls	Assistant Professor
S. Lederman	Associate Professor
E. Levi	Professor
R. Pepper	Research Associate
S. Rosenbaum	Assistant Professor
E. L. Rubin	Associate Professor
P. E. Serafim	Assistant Professor
P. M. Sforza	Assistant Professor
J. Shmoys	Associate Professor
F. Stone	Instructor
N. Trentacoste	Research Assistant
D. S. Wilson	Assistant Professor

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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
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and
Office of Naval Research, Washington, DC

13. ABSTRACT

This report contains a compilation of abstracts of papers which were either accepted for publication or were published. The papers are on the subjects of Fluid Dynamics, Electromagnetics and Plasmas. The work described was carried out under an ARPA contract, Order No. 529. This report also contains a listing of papers submitted to journals, lectures, internal reports and staff activities.

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